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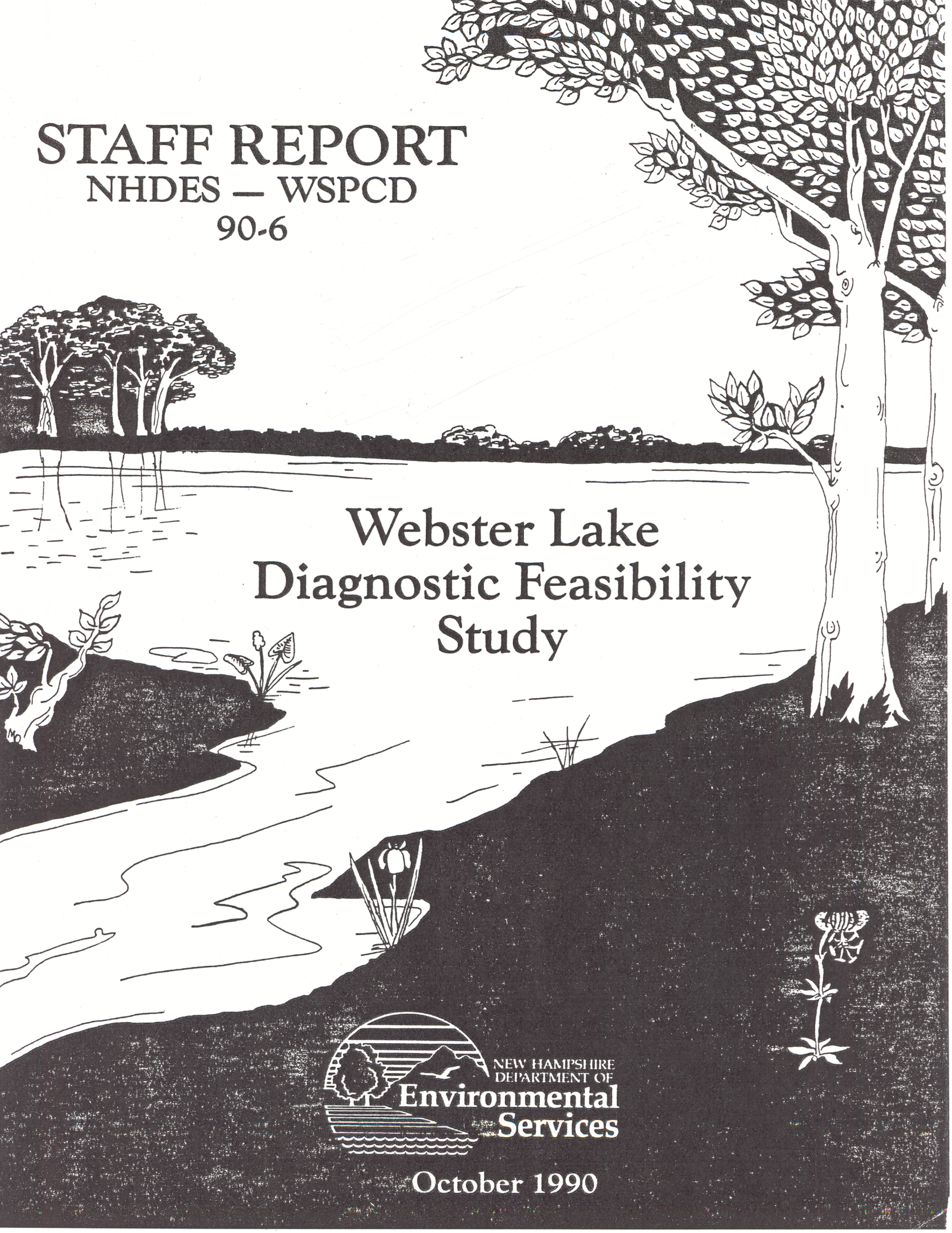

Webster Lake Diagnostic Feasibility Study

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

October 1990

State of New Hampshire
DEPARTMENT OF ENVIRONMENTAL SERVICES
WATER SUPPLY & POLLUTION CONTROL DIVISION

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June 28, 1991

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Dear Mr. Howard:

Transmitted herewith is the Phase I Diagnostic/Feasibility Study for Webster Lake, Franklin, New Hampshire. This report was prepared, in part, under the Clean Water Act, through a Section 314 Environmental Protection Agency Grant. This report culminates a fifteen month period of lake and tributary monitoring, and watershed evaluations. The main focus of this project was Sucker Brook, the most significant source of water and phosphorus to Webster Lake. Hydrologic and phosphorus budgets were constructed for the Sucker Brook sub-watershed and Webster Lake to protection potential phosphorus sources. Sediment cores were analyzed to estimate the impact of sediment - released phosphorus to the water column.

Based on the biological and chemical assessment, and the modeling techniques employed, Webster Lake falls into the mesotrophic classification scheme. Each of the significant phosphorus sources to Sucker Brook have been delineated. Internal phosphorus loading has been documented and determined to be a factor in lake quality degradation.

The feasibility section included an overview on the latest restoration and preservation techniques and their applicability to Webster Lake. The feasibility section focuses attention on decreasing non-point sources of pollutants to Sucker Brook and Webster Lake.

Respectively submitted

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ABSTRACT

The Webster Lake/Sucker Brook Diagnostic/Feasibility study presents fifteen months of physical, chemical and biological data. This data has been utilized to determine feasible and cost-effective means of preserving and, if necessary, restoring Webster Lake. Because of this study, limnologists now have a better understanding of the aquatic ecosystem of Webster Lake and Sucker Brook. This study has increased our knowledge of the phosphorus sources to Sucker Brook.

The study accomplished all the objectives for which it was designed. The Study:

1. Identified the historical and existing quality of Webster Lake;
2. Identified the stream quality of Sucker Brook;
3. Compared trophic models that classified Webster Lake;
4. Developed hydrologic and phosphorus budgets for the Sucker Brook subwatershed and Webster Lake;
5. Documented significant sources of phosphorus to Sucker Brook;
6. Identified the importance of the lake's sediments to supply internal phosphorus loading to the lake;
7. Reviewed current lake restoration techniques and researched the feasibility of each method upon the lake;
8. Reviewed many watershed protection measures that will help to preserve the lake; and
9. Made recommendations that will help improve lake quality and lessen the eutrophication process.

The results and recommendations of the Webster Lake/Sucker Brook Diagnostic/Feasibility study provide a basis for lake preservation and possible implementation of lake restorative actions.

Although this project has been successful in accomplishing its goals, only upon the implementation of the study's recommendations are implemented, will the project be a complete success.

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SUMMARY

A. Introduction

The Webster Lake/Sucker Brook study began in October of 1987 as a result of a Section 314, Clean Lakes Program grant.

The Webster Lake watershed spans two municipalities in the south-central portion of the Lakes Region, New Hampshire. The watershed is dominated by Highland Lake in Andover, and Webster Lake in Franklin. The two lakes are connected by Sucker Brook, which drains about 80% of the entire watershed area and is responsible for approximately 63% of the phosphorus load to Webster Lake during a normalized year.

The goal of the diagnostic study was to determine the phosphorus inputs to Sucker Brook and identify the problem areas of significant phosphorus loading to the brook.

The goal of Section X (Feasibility of Restorative Actions) is to evaluate the methods that can be utilized to preserve and, if necessary, restore Webster Lake, and to recommend the more feasible, cost-effective methods for implementation.

B. Study Approach

Prior to recommendations being made for protective and restorative measures a fuller understanding of such processes as lake flushing rates, groundwater influences, watershed utilization, sediment characteristics and nutrient sources had to be achieved. To this end, biologists began a 15 month study to document the physical, chemical and biological processes of Webster Lake and its main tributary Sucker Brook.

1. Physical, Chemical, and Biological Monitoring

Measurements of water chemistry, plankton populations, chlorophyll-a, and transparency were recorded. An inventory of macrophytic growth was documented, and a detailed map and evaluation of the pond's littoral areas were completed. Sediment cores were extracted and analyzed for specific metals and phosphorus. Land use, topographical ground cover, and soils maps for the entire watershed were prepared.

2. Hydraulic Budget

The hydraulic budget for the gaging period (January through December, 1988) quantified all significant sources of flow into Sucker Brook by gaging tributaries and outlets, estimating direct surface runoff, measuring precipitation and evaporation, and estimating groundwater seepage rates.

3. Nutrient Budget

Phosphorus, the primary factor limiting plankton growth, was determined through water quality sampling and analysis of many of the sources quantified in the hydraulic budgets. Groundwater, atmospheric dryfall and direct runoff inputs were estimated. Phosphorus loading to the lake from near-shore septic systems was also estimated by conducting sanitary surveys around the lake and subwatershed. The quantity of water column and sediment phosphorus concentrations was calculated, and nutrient budgets were prepared for 1988.

4. Lake Modelling

The determination of the trophic state of a lake involves a comparison of the actual total phosphorus loading to the lake with the maximum loadings that the lake can tolerate before excessive macrophyte growth occurs and transparency diminishes. A trophic state model is a mathematical relationship which, by incorporating such factors as phosphorus loading and hydraulic retention time, allows a lake to be classified as oligotrophic, mesotrophic, or eutrophic. Four different classification methods were utilized and their results and compared for this study.

C. <u>Study Results</u>

1. Chemical and Biological Properties

Webster Lake is a dimictic lake, with isothermal conditions occurring twice each year. Anoxic conditions occur in the hypolimnion from June through mid-August. Anoxic conditions are present in the water column below a depth of 8 meters.

The lowest tributary pH was at Three Brooks while the highest was at Reep Farm Station. Cilley Hill Brook had the lowest consistent pH values. Acid neutralizing capacity (ANC) data was limited from seasonal tributaries. Cilley Hill and Bald Hill Brooks had lower ANC values than observed at other stations.

Epilimnetic pH ranged from 6.70 to 7.13 during the monitoring period. Metalimnetic pH values were 0.1 to 0.5 units lower than epilimnion values. Most observations of ANC in Webster Lake ranged from 7.0 to 7.9 mg/L as $CaCO_3$.

Specific conductance ranged from 20.0 umhos/cm (Cilley Hill Brook) to 244.2 umhos/cm (Clay Pond Brook). In-lake specific conductance mostly ranged between 40.0 and 55.0 umhos/cm. Hypolimnetic conductivity was slightly higher during anoxic conditions occuring June through August.

Median monthly chloride concentrations ranged from below detection (< 2.0 mg/L) to 33.0 mg/L. Tributary concentrations were lower than those observed at Sucker Brook Stations. In-lake chloride concentration ranged between 5.0 and 6.0 mg/L, although data is limited.

Median tributary sulfates ranged from 1.95 mg/L to 14.2 mg/L. The majority of the values fell within 3.0 to 7.0 mg/L. In-lake sulfates ranged between 4.0 and 4.7 mg/L.

Median apparent color of the tributaries ranged from <5 to 70 cpu. Color values observed at Cilley Hill and Apple Farm Brooks was significantly lower than other tributary stations. Emory Pond Brook's color values were higher than those colors observed at other stations.

Monthly in-lake apparent color in the three stratified layers was similar and ranged from 10 to 58 cpu.

Observations of tributary turbidity were statistically similar. All stations exibited a spring increase in median turbidity due to snowmelt and spring storm events.

Median monthly total phosphorus concentrations ranged from values below detection to 76 ug/L at Highland Outlet. The greatest phosphorus concentrations were observed at Emory Pond Brook and Highland Outlet Stations, while the lowest concentrations were observed at Apple Farm and Cilley Hill Brooks.

Monthly in-lake concentrations of total phosphorus range from 7 ug/L to 150 ug/L. The highest in lake concentrations were measured in the hypolimnion.

Nitrate Nitrogen was low at both the tributary and the in-lake stations. Total in-lake Kjeldahl nitrogen (TKN) ranged from 0.08 to 0.17 mg/L. Tributary TKN ranged from below detection limits to 0.42 mg/L. Emory Pond Brook had significantly higher TKN values than the other sampled tributaries.

In-lake phytoplankton density ranged from 900 to 1500 cells/mL and the population was typically dominated by *Asterionella* or *Tabellaria*.

The rotifers *Keratella*, *Kellicottia* and *Polyarthra* were the most common observed species of zooplankton. Microcrustaceae were dominant only during January.

Chlorophyll-*a* concentrations ranged from 2.47 to 7.09 mg/m^3 with the mean chlorophyll-*a* concentration of 6.10 mg/m^3.

2. Hydrologic Budget

Hydrologic budgets were prepared for the Sucker Brook subwatershed and the Webster Lake watershed.

The Highland Lake outlet was the greatest single source of water to Sucker Brook and contributed 33.5 percent of the total inflowing water. Groundwater seepage, bank runoff and seasonal tributaries combined to account for 28 percent of the hydrologic budget. The other contributors were Emory Pond Brook (13.5 percent), Three Brooks (9.8 percent), Cilley Hill Brook (7.9 percent), Bald Hill Brook (5.8 percent) and Apple Farm Brook (1.4 percent).

The detailed hydrologic budget for the 1988 gaging year showed that Sucker Brook contributed 76 percent of the total inflowing water to Webster Lake. The 15 tributaries, precipitation, groundwater and direct overland flow contributed the remaining 24 percent of the annual budget.

3. Nutrient Budget

One of the most important goals of this study was to quantify the various avenues of phosphorus inputs to Sucker Brook. Chapter VII includes an annual phosphorus budget for the 1988 gaging year.

The greatest single contributor of phosphorus to Sucker Brook was the Highland Lake outlet which supplied 30 percent of the phosphorus load. Unmonitored sources, such as seasonal/rain event tributaries and groundwater seepage accounted for 28 percent of the phosphorus flux to Sucker Brook.

Emory Pond Brook was the only other tributary to contribute a significant (26 percent) phosphorus load to Sucker Brook. Those tributaries that supplied less significant phosphorus sources were Three Brooks (7 percent), Bald Hill Brook (5 percent), Cilley Hill Brook (2 percent) and Apple Farm Brook (1 percent).

Monitoring showed that Emory Pond Brook had the greatest storm event enduced export of phosphorus to Sucker Brook. During 1988, Emory Pond Brook was a significant source of phosphorus during high intensity storm events and spring runoff events.

A phosphorus budget conducted on Webster Lake revealed that 75 percent of the phosphorus load to the lake was derived from the lake's tributaries. Other external sources of phosphorus were septic systems (17 percent), wetfall (7 percent) and dryfall (2 percent).

4. Lake Modelling

A summary of the four classification schemes utilized in this study revealed that the New Hampshire Lake Classification System and Carlson's Trophic Status Index (TSI) for Chlorophyll-*a* and Hypolimnetic Phosphorus classify Webster Lake as Mesotrophic. The remaining models, Dillon/Rigler, Vollenweider and Carlson's TSI for Secchi disk and epilimnetic phosphorus classify Webster Lake as border line Mesotrophic/Oligotrophic.

On a permissible loading basis, the Dillon/Rigler model demonstrated that an improved trophic status is obtainable in Webster Lake with a 15 kg Pyr^{-1} reduction in phosphorus loading.

5. Feasibility

This section provides an overview of the most recent available restoration and preservation techniques. Each restoration technique has been divided into methodology, cost/benefits and applicability to effectively produce positive water quality results to Webster Lake.

Lake protection and watershed management are the most feasible methods for preserving Webster Lake. However, lake restoration may prove to be necessary if phosphorus reduction cannot be achieved. The most feasible means of lake protection, watershed management and lake restoration should include the following measures:

1. Shoreland protection ordinance
2. Community education
3. Sewering
4. Pumping and Inspection program for subsurface systems
5. Agricultural Best Management Practices
6. Education program for Hobby farms
7. Emory Pond Brook Monitoring Program
8. Highland Lake outlet monitoring program
9. Best Management Practices program for silviculture
10. Stormwater runoff management
11. Lake Monitoring/Phase II Implementation evaluation